[Notes]

Preliminary Study on Measurement of Air Temperature for Monitoring of Heat Island Phenomenon

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To examine the effects of various conditions on air temperature measurement, air temperature was measured under different conditions at different sites at one six-story building before a network for monitoring air temperature was developed. The mean air temperatures measured at the south-facing sites were higher than those at the roof site and the north-facing sites, while the north-facing sites showed approximately the same mean air temperatures as the roof site. However, the diurnal range observed at the roof site was larger than those observed at the north-facing sites although the air temperature at the roof site was measured in a thermometer shelter. When air temperatures were measured without any shelters, it could provide available data to measure air temperatures in the shade at the north-facing site.

Ⅰ INTRODUCTION

Air temperature has been measured from the standpoint of not only the detection of climate change but also the survey of urban heat islands[1-4]. When air temperature is measured, the site should be selected carefully according to the purpose of the study. When the purpose is to study urban heat islands, the measurements should be taken in an urban area. It is preferable that air temperature be measured 1.5 m above ground by a thermometer which is placed in a thermometer shelter on the grass; however, the optimal conditions cannot always be achieved. In the current study, the different conditions under which air temperatures are measured, including differences in measuring devices, were examined.

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Ⅱ MATERIALS AND METHODS

2.1 Research site and period

In April 2005, air temperatures were measured under different conditions at nine sites at one six-story building, the Hyogo Prefectural Institute of Public Health and Environmental Sciences. Air temperature was measured at the following sites and under the following conditions:

Site A: On the roof (about 25 m above ground), with the thermometer placed inside a thermometer shelter. The area where the thermometer shelter was placed was covered with a tarpaulin.

Site B: On the sixth-floor south-facing balcony (about 21 m above ground).

Site C: On the sixth-floor north-facing balcony (about 21 m above ground).

Site D: On the fifth-floor south-facing balcony (about 17 m above ground).

Site E: On the fifth-floor north-facing balcony (about 17 m above ground).

Site F: On the third-floor south-facing balcony (about 9 m above ground).

Site G: On the third-floor north-facing balcony (about 9 m above ground).
Site H: The first-floor south-facing veranda.*
Site I: The first-floor north-facing veranda.

On each balcony and veranda, thermometers were places in the shade and, where possible, away from air conditioners.

2.2 Measurement devices and frequency

Air temperatures were measured by two kinds of thermometers (type I: Thermo Recorder TR-72U, T&D Corporation, Nagano, Japan; type II: Thermochron type G, KN Laboratories, Inc., Osaka, Japan). The measurement resolutions of the Thermo Recorder TR-72U and Thermochron type G are 0.1℃ and 0.5℃, respectively. The measurement accuracies of Thermo Recorder TR-72U and Thermochron type G are ±0.3℃ and ±1℃, respectively.

Air temperatures were measured at 10-minute intervals, and hourly mean air temperatures were used for analyses.

Ⅲ RESULTS AND DISCUSSION

3.1 Comparison of measurement devices

The differences in daily air temperatures as measured with the two devices are shown in Fig.1. The vertical and horizontal axes show the differences in air temperature according to the device used and the time of measurement shown by day, respectively. The daily mean, daily maximum, and daily minimum air temperature are depicted in Fig.1 (a), (b), and (c), respectively. The differences in daily mean air temperature (Fig.1 (a)) were between approximately -0.2℃ and +0.7℃, which shows that air temperature can be measured within the precision of each device shown in 2.2. Each site had site-specific differences; i.e., the differences were constant and without large variations, which shows that the differences were determined by a device-specific quality. The differences in the daily maximum air temperature (Fig.1 (b)) were between approximately -1.0℃ and +1.0℃, showing that the daily maximum air temperature can also be measured within the precision of each device, though variations in the

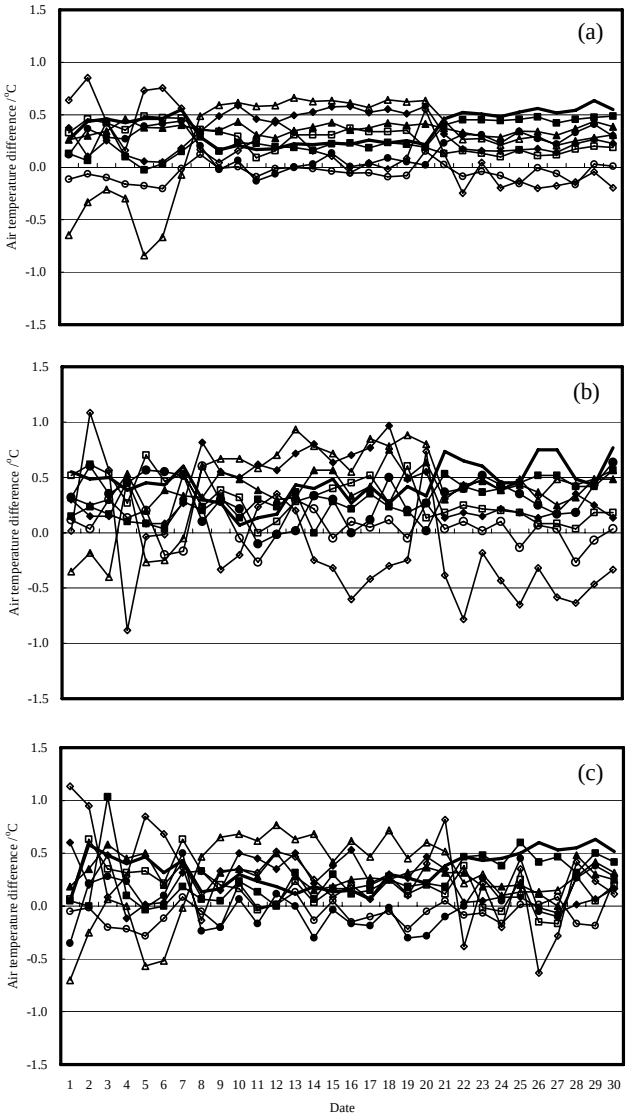

Figure 1 Differences in daily air temperatures as measured with the two devices.
(a), (b), and (c) are drawn for daily mean, daily maximum, and daily minimum air temperature, respectively. No mark, open circle (○), filled circle (●), open square (□), filled square (■), open triangle (△), filled triangle (▲), open rhombus (◇), and filled rhombus (◆) shows Site A, Site B, Site C, Site D, Site E, Site F, Site G, Site H, and Site I, respectively.

daily maximum were larger than those of the daily mean air temperature. The differences in daily minimum air temperature (Fig.1 (c)) were between approximately -0.3℃ and +0.8℃, which shows that the daily minimum air temperature can also be measured within the precision of each device. Variations in the daily minimum were smaller than those of the daily maximum air temperature. Thus,

the differences in measurement devices are conceivably within the precision of each device.

3.2 Comparison of sites

3.2.1 Time-varying comparison

The differences in air temperature between the roof site (Site A) and the floor sites (Sites B ～ I) are shown in Fig.2. The vertical axis shows the differences in air temperature, i.e., the air temperature at Site A minus the air temperatures at Sites B ～ I, and the horizontal axis shows the time by hour. Large open circles show the time of 0:00. As shown in Fig.2, the differences in air temperature between the roof site and the south-facing sites generally showed negative values; in other words, the air temperatures at the south-facing sites (Sites B, D, F, H) were higher than the air temperature at the roof site irrespective of the time although a diurnal variation was observed. In contrast, the differences in air temperature between the roof site and the north-facing sites (Sites C, E, G, I) showed both a negative value and a positive value, depending on the time. The difference in air temperature showed a positive value in the daytime and a negative value at night; in other words, the air temperatures at the roof site were higher and lower than those at the north-facing sites during the day and at night, respectively.

Figure3 (a) demonstrates the differences in daily mean air temperature between the roof site (Site A) and the floor sites (Sites B ～ I). As for the north-facing sites (Sites C, E, G, I), the differences in daily mean air temperature were approximately within ±1℃, while for the south-facing sites (Sites B, D, F, H), the daily mean air temperatures at the south-facing sites were generally higher, in a range of 2.5℃, than those at the roof site.

Figure3 (b) demonstrates the differences in daily maximum air temperature between the roof site (Site A) and the floor sites (Sites B ～ I). The differences in daily maximum air temperature between the roof site and the north-facing sites

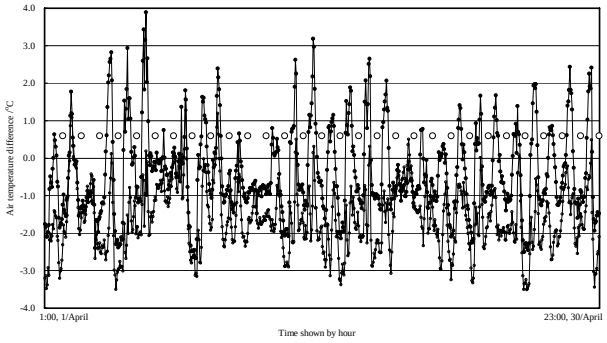

Figure 2　Differences in air temperature between the roof site and the mean of south-facing sites (●), north-facing sites (○) based on hourly mean air temperature. Large open circles show the time of 0:00.

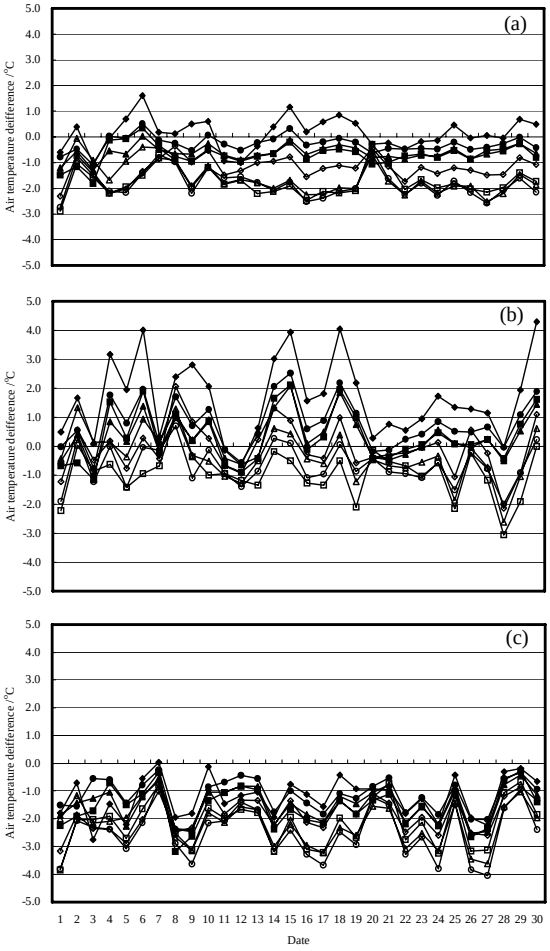

Figure 3　Differences in air temperature between the roof site(Site A)and the floor sites(Sites B～I) (a), (b), and (c) are drawn for daily mean, daily maximum, and daily minimum air temperature, respectively. Open circle (○), filled circle (●), open square (□), filled square (■), open triangle (△), filled triangle (▲), open rhombus (◇), and filled rhombus (◆) shows Site A – Site B, Site A - Site C, Site A - Site D, Site A - Site E, Site A - Site F, Site A - Site G, Site A - Site H, and Site A - Site I, respectively.

(Sites C, E, G, I) were between approximately -1℃ and +4℃, while those between the roof site and the south-facing sites (Sites B, D, F, H) were between approximately -3℃ and +1℃.

The differences in the daily minimum air temperatures between the roof site (Site A) and the floor sites (Sites B ～ I) are shown in Fig.3 (c). The roof site mostly showed lower air temperatures than the floor sites. In addition, the differences were larger at the south-facing sites (Sites B, D, F, H). The differences were up to 4℃ at the south-facing sites and up to 3℃ at the north-facing sites.

3.2.2 Statistical comparison

Some statistical parameters of air temperature are summarized in Table 1. The air temperatures at the south-facing sites were higher than those at the roof site and the north-facing sites, which is consistent with the result shown in 3.2.1. At the roof site, not only the standard deviation (S.T.D.) but also the relative standard deviation, defined as S.T.D./mean, was larger than those at other sites, showing that the diurnal range of air temperature at the roof site was larger than those at other sites although the air temperature at the roof site was measured in a thermometer shelter.

Table 1 Some statistical parameters of air temperature.

	n	Mean	Median	Minimum	Maximum	S.T.D.[1)]	R.S.D.[2)]	(Max.-Min.)/mean
Site A	720	15.3	15.7	6.0	27.3	3.7	24.0%	1.39
Site B	720	17.1	17.1	8.8	27.0	3.4	19.7%	1.06
Site C	720	15.6	15.9	7.0	25.4	3.3	21.1%	1.18
Site D	720	17.1	16.9	8.3	27.3	3.4	20.1%	1.11
Site E	720	16.0	16.3	7.1	25.7	3.3	20.7%	1.16
Site F	720	17.1	17.2	8.8	26.7	3.4	19.7%	1.05
Site G	720	16.0	16.2	7.5	25.8	3.3	20.5%	1.15
Site H	720	16.5	16.6	8.8	26.2	3.3	19.7%	1.05
Site I	720	15.2	15.4	7.9	23.0	3.0	19.8%	0.99

1) S.T.D.shows standard deviation.
2) R.S.D.shows S.T.D./mean.

Ⅳ CONCLUSION

The conditions under which air temperature is measured were examined in preparation for the development of a network to monitor air temperature. At a six-story building, air temperatures measured at the south-facing sites showed higher mean values than those measured at the north-facing sites and the roof site. In contrast, air temperatures measured at the north-facing sites showed mean values similar to those measured in the roof site. However, the diurnal range at the roof site was larger than those at the north-facing and south-facing sites. When air temperatures were measured without any shelters, it could provide available data to measure air temperatures in the shade at the north-facing site.

The error produced by using different devices was within the precision of each device.

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「ノート」
ヒートアイランド現象解明に係る気温測定に関する予備的研究

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要 約

気温測定網を構築するにあたり，気温測定の条件を検討するために予備実験として,6階建てビル内の異なる条件（高さ及び方位）の地点で気温測定を行った．南側に面した地点で測定された平均気温は北側に面した地点及び屋上で測定された平均気温よりも高い値を示した．一方，北側に面した地点で測定された平均気温は屋上で測定された平均気温とほぼ同じ値を示す一方，北側に面した地点での日較差は屋上での日較差よりも小さい値を示した．このことから，百葉箱等が利用できない場合，ベ

ランダ等の雨のかからない，北側の日陰で気温を測定することにより，ある程度利用可能な気温データを測定できることが示された.